Ice Breakup in Two Alaskan Rivers

Identification

1. Description

This regional feature highlights the annual date of river ice breakup for two rivers: the Tanana River at Nenana, Alaska, and the Yukon River at Dawson City, Yukon Territory, Canada (the first town upstream from the Alaskan border). These data are available from 1917 (Tanana) and 1896 (Yukon) to present. The date of ice breakup is affected by several environmental factors, including air temperature, precipitation, wind, and water temperature. Tracking the date of ice breakup over time can provide important information about how the climate is changing at a more localized scale. Changes in this date can pose significant socioeconomic, geomorphic, and ecologic consequences (Beltaos and Burrell, 2003).

2. Revision History

May 2014:	Feature published.
June 2015:	Updated feature on EPA's website with data through 2015.
August 2016:	Updated feature with data through 2016.

Data Sources

3. Data Sources

This feature presents the annual ice breakup data collected as part of the Nenana Ice Classic and Yukon River Breakup competitions. The Nenana Ice Classic is an annual competition to guess the exact timing of the breakup of ice in the Tanana River. Since its inception in 1917, the competition has paid more than $11 million in winnings, with a jackpot of $300,000 in 2016. A similar betting tradition occurs with the Yukon River in Dawson City, where ice breakup dates have been recorded since 1896.

4. Data Availability

All of the ice breakup data used are publicly available. Nenana Ice Classic data from 1917 to 2003 come from the National Snow and Ice Data Center (NSIDC), which maintains a comprehensive database at: http://nsidc.org/data/lake_river_ice. Data from 2004 to present were obtained directly from the Nenana Ice Classic organization; see the "Brochure" tab at: www.nenanaakiceclassic.com. Ice breakup dates from 1896 to present for the Yukon River are maintained by Mammoth Mapping and are available at: www.yukonriverbreakup.com/statistics. River ice breakup dates for the Nenana site on the Tanana River, as well as several other Alaskan rivers, are also recorded by the National Weather Service, Alaska-Pacific River Forecast Center, at: http://aprfc.arh.noaa.gov/index_breakup.php.

Methodology

5. Data Collection

To measure the exact time of ice breakup, residents in Nenana and Dawson City use tripods placed on the ice in the center of the river. This tripod is attached by a cable to a clock on the shore, so that when the ice under the tripod breaks or starts to move, the tripod will move and pull the cable, stopping the clock with the exact date and time of the river ice breakup. In Nenana, the same wind-up clock has been used since the 1930s. Prior to the tripod method, observers watched from shore for movement of various objects placed on the ice. Dawson City also used onshore observers watching objects on the ice during the early years of the competition. For more information about these competitions, see: www.nenanaakiceclassic.com and: www.yukonriverbreakup.com/statistics.

6. Derivation

Figure 1 plots the annual ice breakup dates for each river. For some years, the original data set included the exact time of day when the ice broke, which could allow dates to be expressed as decimals (e.g., 120.5 would be noon on Julian day 120, which is the 120th day of the year). Some other years in the data set, however, did not include a specific time. Thus, for consistency, EPA chose to plot and analyze integer dates for all years (e.g., the example above would simply be treated as day #120).

Some data points were provided in the form of Julian days. In other cases where data points were provided in the form of calendar dates (e.g., May 1), EPA converted them to Julian days following the same method that was used to calculate Julian days in the original data set. By this method, January 1 = day 1, etc. The method also accounts for leap years, such that April 30 = day 120 in a non-leap year and day 121 in a leap year, for example. Figure 1 actually plots Julian dates, but the corresponding non-leap year calendar dates have been added to the y-axis to provide a more familiar frame of reference. This means that an ice breakup date of April 30 in a leap year will actually be plotted at the same level as May 1 from a non-leap year, for example, and it will appear to be plotted at May 1 with respect to the y-axis.

No annual data points were missing in the periods of record for these two rivers. This feature does not attempt to portray data beyond the time periods of observation.

7. Quality Assurance and Quality Control

The method of measuring river ice breakup ensures that an exact date and time is captured. Furthermore, the heavy betting tradition at both locations has long ensured a low tolerance for errors, as money is at stake for the winners and losers.

Analysis

8. Comparability Over Time and Space

River ice breakup dates have been recorded annually for the Tanana River since 1917 and for the Yukon River since 1896, using a measuring device or other objects placed on the river ice at the same location every year. This consistency allows for comparability over time.

9. Data Limitations

Factors that may impact the confidence, application, or conclusions drawn from the data are as follows:

1. While the record of river ice breakup dates is comprehensive, there are no corresponding environmental measurements (e.g., water conditions, air temperature), which limits one's ability to directly connect changes in river ice breakup to changes in climate.

2. Other factors, such as local development and land use patterns, may also affect the date of ice breakup. The two locations featured here, however, are fairly remote and undeveloped, so the ice breakup dates are more likely to reflect natural changes in weather and climate conditions.

10. Sources of Uncertainty

This regional feature is likely to have very little uncertainty. The measurements are simple (i.e., the day when the ice starts to move at a particular location) and are collected with a device rather than relying on the human eye. Measurements have followed a consistent approach over time, and the competitive nature of the data collection effort means it is highly visible and transparent to the community, with low tolerance for error.

11. Sources of Variability

Natural climatic and hydrologic variations are likely to create year-to-year variation in ice breakup dates. For a general idea of the variability inherent in these types of time series, see Magnuson et al. (2000) and Jensen et al. (2007)—two papers that discuss variability and statistical significance for a broader set of lakes and rivers.

12. Statistical/Trend Analysis

EPA calculated long-term trends in river ice breakup for the Tanana and Yukon rivers by ordinary least-squares linear regression to support statements in the "Key Points" text. Both long-term trends were statistically significant at a 95-percent confidence level:

- Tanana regression slope, 1917–2016: -0.078 days/year ($p < 0.001$).
- Yukon regression slope, 1896–2016: -0.060 days/year ($p < 0.001$).

Both of these regressions are based on Julian dates, so they account for the influence of leap years (see Section 6 for more discussion of leap years). These regressions are also based on integer values for all years. As described in Section 6, some of the available data points included time of day, but others did not, so the graph and the regression analysis use integer dates for consistency.

References

Beltaos, S., and B.C. Burrell. 2003. Climatic change and river ice breakup. Can. J. Civil Eng. 30:145–155.

Jensen, O.P., B.J. Benson, and J.J. Magnuson. 2007. Spatial analysis of ice phenology trends across the Laurentian Great Lakes region during a recent warming period. Limnol. Oceanogr. 52(5):2013–2026.

Magnuson, J., D. Robertson, B. Benson, R. Wynne, D. Livingstone, T. Arai, R. Assel, R. Barry, V. Card, E. Kuusisto, N. Granin, T. Prowse, K. Steward, and V. Vuglinski. 2000. Historical trends in lake and river ice cover in the Northern Hemisphere. Science 289:1743–1746.